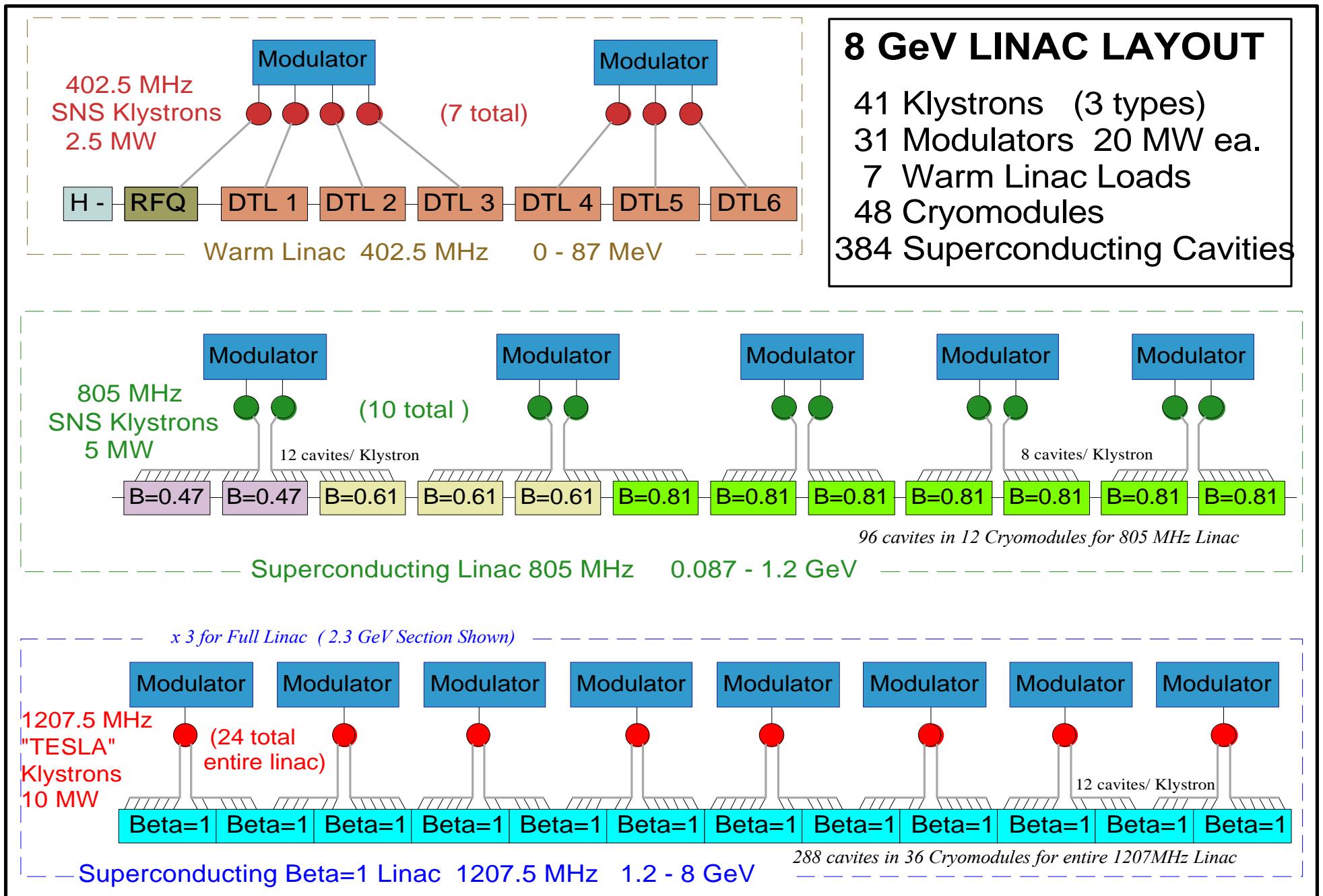


8 GeV Linac Design Study Parameters List

Working Version V.1.7

With Reference Parameters from Spallation Neutron Source Parameter List Rev.6 (Oct 2000)

PRIMARY PARAMETERS		8 GeV Linac		Spallation Neutron Source	
Linac Particle Type	H - ions or Electrons	selectable on pulse-by-pulse basis		H -	
Linac beam kinetic energy	8 GeV			1 GeV	
Linac Beam power	2 MW	sum of H- and e- at 8 GeV		1.56 MW	
Linac Pulse repetition rate	10 Hz	combined rate for H- and e-		60 Hz	
Linac macropulse width	1 ms			1 ms	
Linac current (avg. in macropulse)	26 mA			26 mA	
Linac current (peak in macropulse)	28 mA			38.2 mA	
Linac Beam Chopping factor in macropulse	93 %	adiabatic capture with 700ns abort gap		68 %	chopped to fill RF bucket
Linac Particles per macropulse	1.56E+14 H- or e-			1.56E+14 H-	
Linac Charge per macropulse	26 uC			26 uC	
Linac Energy per macropulse	208 kJ			26 kJ	
Linac average beam current	0.26 mA			1.56 mA	1.4 mA on target
Linac beam macropulse duty factor	1 %			6 %	
Linac RF duty factor	1.2 %			7.2 %	
Linac average beam current	0.26 mA			1.56 mA	1.4 mA on target
Linac Active Length including Front End	692 m	Excludes possible expansion length		258 m	Excludes space for 9 more cryomodules
Linac Beam-floor distance	1.27 m	50.0 in		1.27 m	50.0 in
Linac Depth Below Grade	9 m	same as Fermilab Main Injector			
Transfer Line Length to Ring	280 m	for MI-302 Injection point			
Transfer Line Total Bend	15.76 deg	net bend is half of this			
Ring circumference	3319.4 m	Fermilab Main Injector			
Ring Beam Energy	8-120 GeV	MI cycle time varies with energy			
Ring Beam Power on Target	2 MW	~ independent of MI Beam Energy			
Ring Circulating Current	2.3 A				
Ring cycle time	0.2-1.5 sec	depends on MI beam energy & flat-top			
Ring Protons per Pulse on Target	1.50E+14 protons				
Ring Charge per pulse on target	25 uC				
Ring Energy per pulse on target	200-3000 kJ	at 8-120 GeV			
Ring Proton pulse length on target	10 us	1 turn, or longer with resonant extraction			
LINAC SEGMENT LENGTHS		8 GeV Linac		Spallation Neutron Source	
Ion Source (H- and P)	Length (m)	Eout (MeV)	# Modules	Length (m)	Eout (MeV)
Low-Energy Beam Transport (LEBT)	0.0 m	0.065		0.0 m	0.065
Radio-Frequency Quad (RFQ)	0.1 m	0.065		0.1 m	0.065
Medium-Energy Beam Transport (MEBT)	3.8 m	2.5	4	RFQ modules	
Drift Tube Linac (DTL)	0.7 m	2.5	1	buncher cavity	
Low Beta=0.47 SCRF (or CCL for SNS)	36.6 m	86.8	6	DTL Tanks	
Medium Beta=0.61 SCRF	21.7 m	175	2	Cryomodules	
High Beta=0.81 SCRF	33.6 m	402	3	Cryomodules	
Beta=1 SCRF	89.5 m	1203	7	Cryomodules	
LINAC ACTIVE LENGTH	506.2 m	8000 MeV	36	Cryomodules	
Transfer Line to Ring	692 m	8000 MeV			
Tunnel to Upstream Eqpt. Drop Hatch	280 m	8000	14	half-cells (quads)	
TUNNEL TOTAL LENGTH	30 m				
	1002 m				
				258 m	1000 MeV
				170 m	
				428 m	

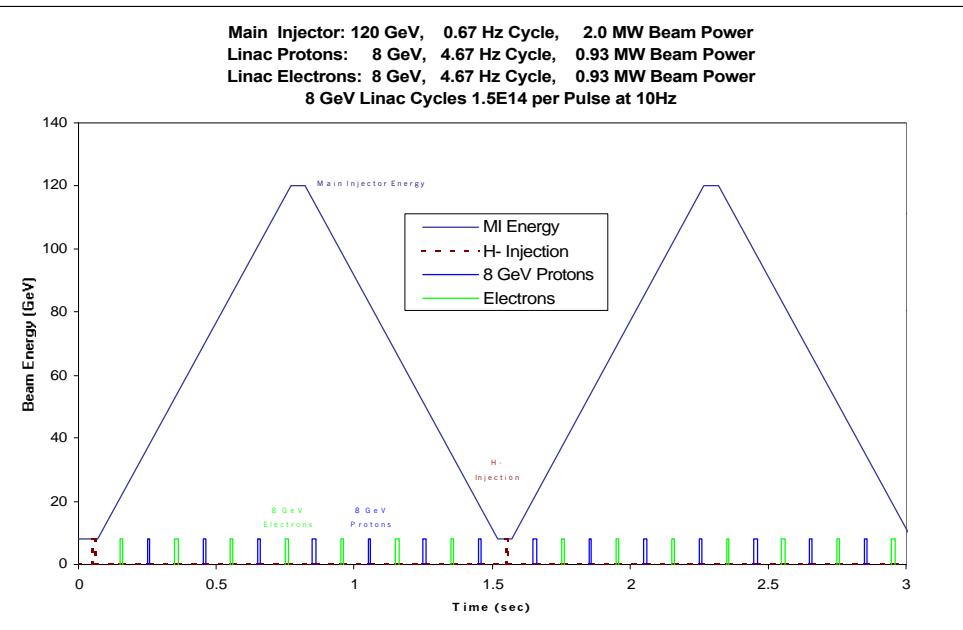


Main Injector Cycles Supported**8 GeV Linac**

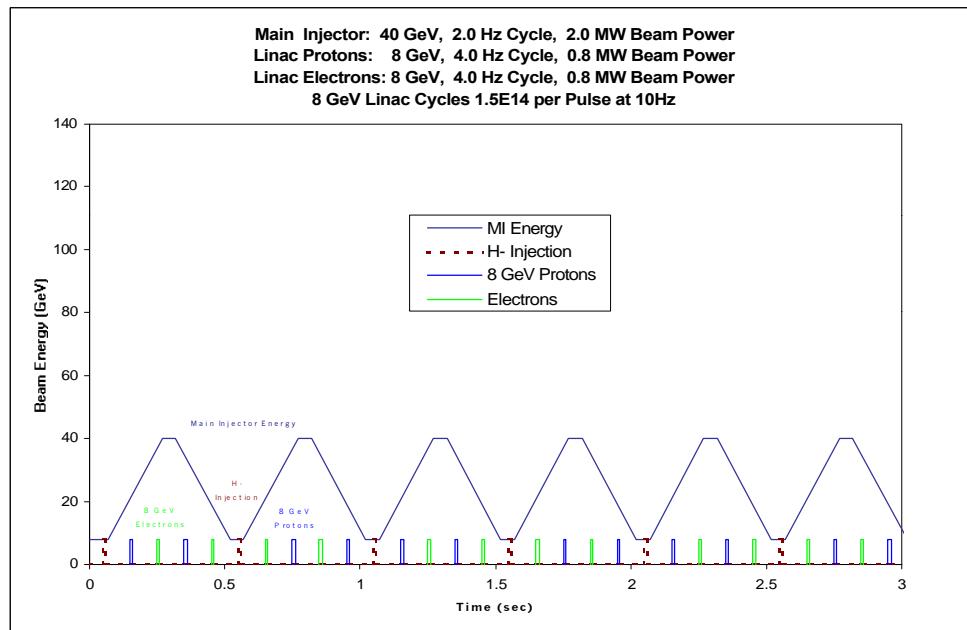
	Typical User	Cycle Time	Spill Time (typ)	Beam Power (max)	Simultaneous e- linac power
8 GeV Accumulation (Main Injector)	BooNe	0.1 sec	10 usec	2 MW	2 MW (P + e-)
8 GeV Long Pulse	Matl. Sci.	0.1 sec	1 msec	2 MW	2 MW (P + e-)
8 GeV Continuous Spill (Recycler)	8 GeV FT	0.1-100 sec	0.1-100 sec	20kW-2MW	2 MW
40 GeV Rapid Cycle	40 GeV nu	0.5 sec	10us - 50ms	2 MW	1.6 MW
120 GeV Standard Cycle	Meson120	1.5	100ms	2 MW	1.87 MW
150 GeV Tevatron FT Injection	1 Tev Nu	1.8	10 usec	2 MW	1.9 MW
150 GeV Collider Injection	VLHC	1.5	10 usec	40kW	1.9 MW

120 GeV Main Injector Cycle

With Interleaved 8 GeV Electrons and Protons/H-

**40 GeV Main Injector Fast Cycle**

With Interleaved 8 GeV Electrons and Protons/H-



FRONT END (H-)		8 GeV Linac		Spallation Neutron Source	
Ion type	H-minus			H minus	
Max Pulse Rate (H-)	10 Hz			60 Hz	
Output energy	2.5 MeV	RFQ output		2.5 MeV	RFQ output
Length	7.52 m	From IS outlet flange to DTL		7.52 m	From IS outlet flange to DTL
Output peak current	28 mA			38 mA	
ION SOURCE AND LEBT					
Output energy	65 keV			65 keV	
LEBT length	0.12 m			0.12 m	
Output peak current	35 mA	Assuming 80% front end transmission		48 mA	Assuming 80% front end transmission
Ion source type	RF volume	Multicusp Cs-enhanced		RF volume	Multicusp Cs-enhanced
Electron suppression	magnetic	Interception at low energy		magnetic	Interception at low energy
LEBT focusing type	electrostatic			electrostatic	
Estimated output rms norm H & V emit.	0.2 pmm-mrad			0.2 pmm-mrad	
Ion source lifetime	18 weeks	?? Scale by pulse rate from SNS ??		3 weeks	Maintenance cycle
Ion source replacement time	2 hours	With conditioned replacement ion source		2 hours	With conditioned replacement ion source
LEBT CHOPPER					
Type	LBL/SNS			LBL/SNS	
Purpose	Establish 700ns abort kicker rise time gap in ring			Assist MEBT Chopper	
Deflection	transverse	uses split focusing electrodes in LEBT		transverse	uses split focusing electrodes in LEBT
Output peak current	28 mA			38 mA	
ON/OFF beam current ratio	5E+03	TBD			
Rise, Fall Time	< 20 ns	1% - 99%		< 20 ns	1% - 99%
Operating energy	< 65 keV			< 65 keV	
Operating Voltage	10 kV	TBD		~10? kV	
RFQ ACCELERATOR					
Output energy	2.5 MeV			2.5 MeV	
Length	3.76 m	4 modules, incl. LEBT diagnostic plate		3.76 m	4 modules, incl. LEBT diagnostic plate
Output peak current	28 mA			38 mA	
RF frequency	402.5 MHz			402.5 MHz	
Nominal aperture radius	3.5 mm			3.5 mm	
Rms surface field during macropulse	1.85 Kilpatrick			1.85 Kilpatrick	
Rms macropulse structure power	630 kW	Assumes 67% of Cu Q		630 kW	Assumes 67% of Cu Q
Expected output rms norm H & V emit.	0.21 pi mm-mrad			0.21 pi mm-mrad	
Expected output rms L emittance	0.1 pi MeV-deg	At 402.5 MHz		0.1 pi MeV-deg	At 402.5 MHz
FRONT END (Electron Option)		8 GeV Linac		Spallation Neutron Source	
Model	TTF2 Photoinjector	modified for 1207 MHz			
Repetition Rate (max)	10 Hz				
Macropulse Length	1 msec				
Average Current During Macropulse	26 mA				
Beam Merging with H- Linac	at Beta=0.81 Cryomodules (TBD)				
Proton Beam Energy at merging	386 MeV	2 "TESLA" Cryomodules in e- beamline			

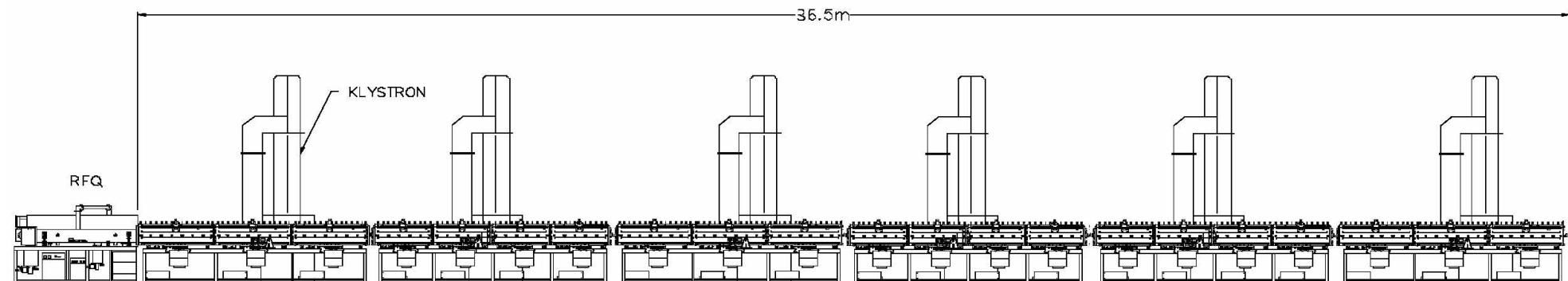
MEBT (H- or P)	8 GeV Linac	Spallation Neutron Source
Ion type	H-minus	H minus
Output energy	2.5 MeV	2.5 MeV
Length	0.7 m	3.64 m
Output peak current	28 mA	38 mA
Number of quadrupoles	2	14
Number of quadrupole PS	2	11
Quad clear bore diameter	32 mm	32 & 42 mm
Maximum integrated quad gradient	2.4 T	2.4/1.9 T
Number of two-plane beam steerers	2	6
Number of steerer PS	4	12
Number of rebuncher cavities	1	4
Rebuncher cavity frequency	402.5 MHz	402.5 MHz
Maximum rebuncher peak voltage integral	120 kV	120 kV
H & V norm output emittance w/errs	0.27 pi mm-mrad	0.27 pi mm-mrad
L norm output emittance w/errs	0.13 pi MeV-deg	0.13 pi MeV-deg
Expected max quad rms gradient error	<1 %	<1 %
Max quad rms position error on sub-raft	0.025 mm	0.025 mm
Max sub-raft rms pos. err on major support	0.04 mm	0.04 mm
Quad rms Roll error expected max	0.06 mrad	0.06 mrad
Quad rms Yaw error expected max	0.06 mrad	0.06 mrad
Quad rms Pitch error expected max	0.6 mrad	0.6 mrad
MEBT RF SYSTEM		
RF frequency	402.5 MHz	402.5 MHz
RF power	20 kW	20-40 kW
RF amplitude rms error	2 %	2 %
RF phase rms error	1 degree	1 degree
MEBT TRAVELING WAVE CHOPPERS		
Number of choppers	none	2
Chopper length	-	0.35 m
Full rise/fall time	-	10 ns
Beam-on duty factor	-	68 %
Gap	-	18 mm
Total deflection voltage	-	+/- 2350 V
Post chopper off/on beam-current ratio	-	1.00E-04
two symmetric triplets wired in series Quads 1-4&11-14 small; 5-10 larger Narrow/wide bore Quad poletip windings		

DRIFT-TUBE LINAC (DTL)	8 GeV Linac	Spallation Neutron Source
Output energy	86.8 MeV	86.8 MeV
Duty Cycle (beam)	1 %	6 %
Length	36.569 m	36.569 m
RF frequency	402.5 MHz	402.5 MHz
Average synchronous phase	-37 to -26	-37 to -26
Number of tanks	6	6
Maximum field	1.3 Kilpatrick	1.3 Kilpatrick
Bore radius	12.5 mm	12.5 mm
Focusing structure	FFODDO	FFODDO
Focusing period	6 beta-lambda	6 beta-lambda
Number of quads	147	147
Quadrupole type	permanent magnet	permanent magnet
Integrated quad gradient	1.295 T	1.295 T
Quad location	inside DTs	inside DTs
Number of steering dipoles	24	24
Average operating vacuum pressure	1.80E-07 Torr	1.80E-07 Torr

DTL TANK PARAMS

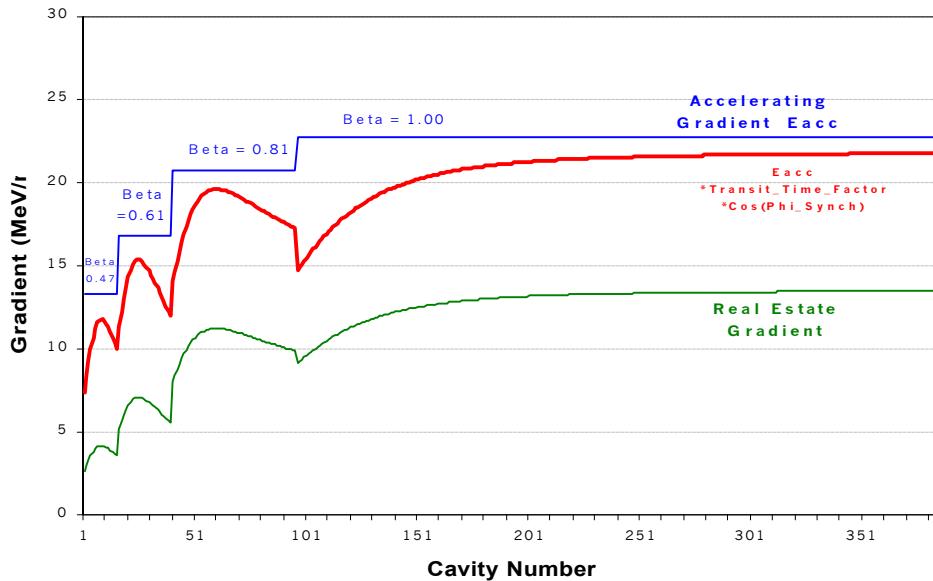
Length between end walls (m)	4.152	6.063	6.324	6.411	6.294	6.341	m
Number of cells	60	48	34	28	24	22	
Number of post couplers	19	23	16	27	23	21	
Energy gain (MeV)	5.023	15.362	16.88	16.771	15.984	14.306	MeV
Stored energy (J)	4.78	16.51	21.84	22.22	22.05	21.47	J
Average E0T (MV/m)	1.518	2.81	2.966	2.907	2.886	2.777	MV/m
Shunt impedance ZT2 MW/m	28.22	45.25	43.54	41.91	40.83	39.03	MW/m
Unloaded Q	35,891	40,074	43,237	42,492	43,429	43,316	
External Q	23,554	26,480	29,468	29,812	29,981	30,863	

DTL Based on AccSys PL-7 Tanks

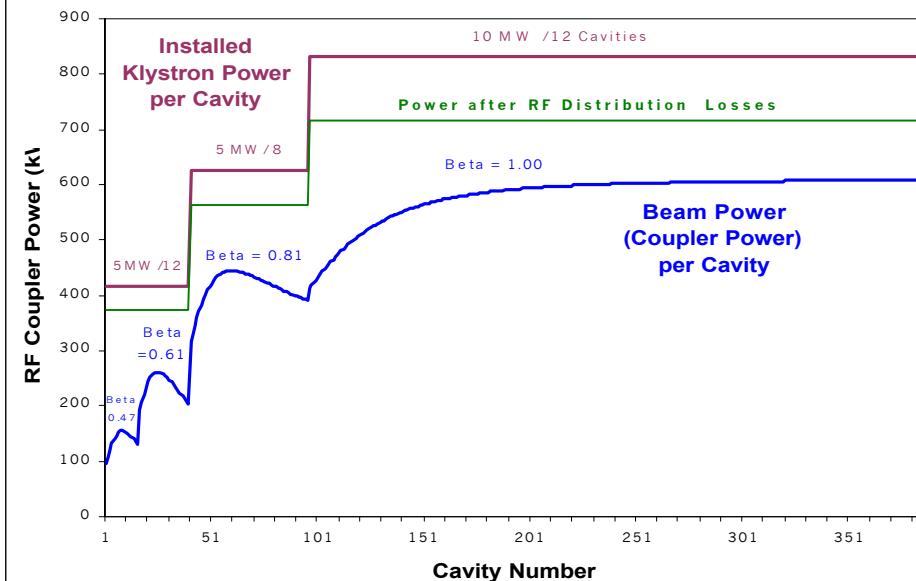


Superconducting RF LINAC		8 GeV Linac		Spallation Neutron Source	
Output energy	8000 MeV			1000 MeV	
Input energy	87 MeV			190 MeV	
Length	651.0 m			157.321 m	23 cryomodules + 22 warm spaces
Number of Cryomodules	48	+1 for optional debuncher		23	
Cryomodule Style	TESLA	no warm spaces between cryomods		CEBAF	warm space between every cryomod
Number of Cavities	384			81	
Cavity Maximum Field Epeak	45 MV/m	TESLA(500)=47, TESLA(800)=70 MV/m		37 MV/m	
Cavity Accelerating Field Eacc	13-23 MV/m	varies along length - see graph			
Cavity Voltage Profile	Constant Gradient			Constant Gradient	
Number of Beta Sections	4			2	
Cryomodule Type (Beta)				MEDIUM	HIGH
Geometrical Beta of Sections	0.47	0.61	0.81	0.61	0.81
RF frequency (MHz)	805	805	805	805	805
Input Energy of each section (MeV)	87	173	386	1321	391.4
Number of Cryomodules for each Beta	2	3	7	11	12
Length of Cryomodule slot for each Beta	10.9 m	11.2 m	12.8 m	5.839 m	7.891 m
Total Cryomodule Length for each Beta	21.7 m	33.6 m	89.5 m	64.229 m	94.692 m
Number of Cells Per Cavity	6	6	6	6	6
Number of Cavities Per Cryomodule	8	8	8	3	4
Number of Cavities per Klystron	12	12	8	1	1
Number of Quads Per Cryomodule	9	5	3	2	2
Quad + BPM Assembly Lengths	0.5 m	0.5 m	0.50 m		warm doublet outside cryomodule
Space between cryomodule valves	0.5 m		cold beam pipe with profile monitor		
Length of differential pumping section	2.35 m		DTL to SRF distance		
Length for additional cryomodules	TBD m				
Number of Klystrons	41		+1 for optional Debuncher Cavity		
Klystron Total Peak Power	290 MW			1.6 m	Warm Space between gate valves
Peak Beam Power	200 MW			2.35 m	CCL to SRF distance
Warm beam pipe vacuum	N/A Torr			71.019 m	nine additional high beta
				81	one Klystron per cavity
				44.6 MW	
				18 MW	
				1.00E-09 Torr	

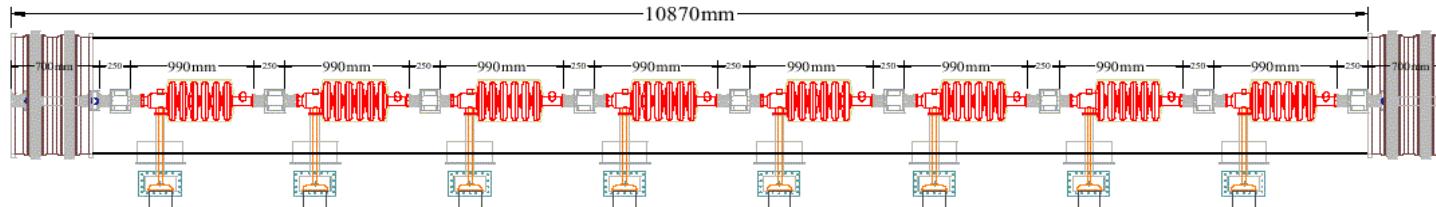
Cavity Accelerating Gradient and Real Estate Gradient
Epeak = 45MV/m in all cavities, Phi_Synch = -25 to -16 degrees



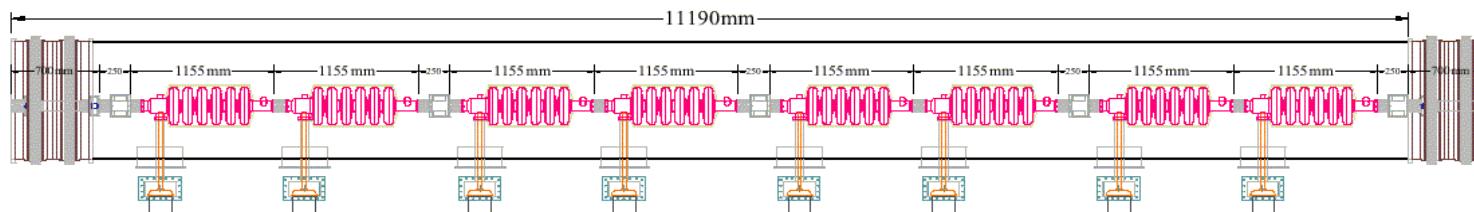
Klystron Power per Cavity and RF Coupler (Beam) Power
Epeak = 45MV/m in all cavities, Phi_Synch = -25 to -16 degrees
Beam Current = 25mA



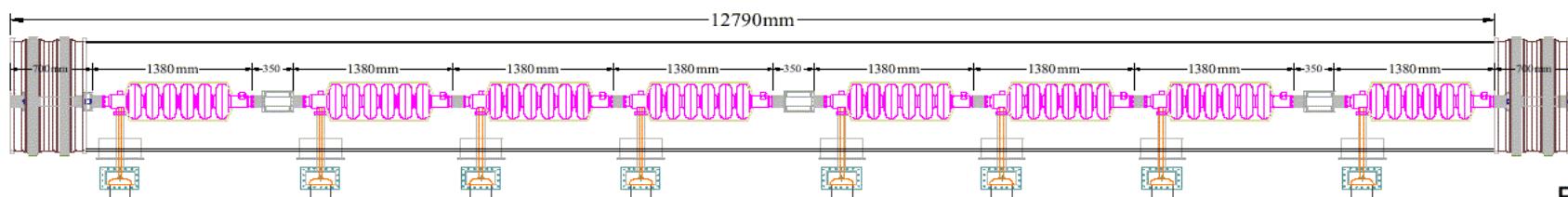
8 GeV Linac Cryomodules - 4 Types



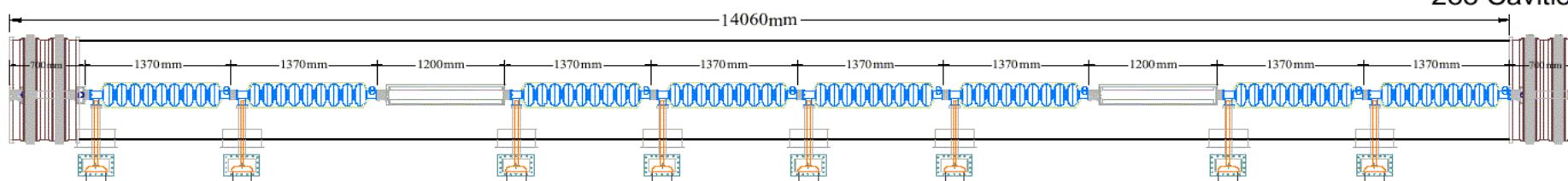
Beta= 0.47
2 Cryomodules
16 Cavities



Beta= 0.61
3 Cryomodules
24 Cavities



Beta= 0.81
7 Cryomodules
56 Cavities



Beta= 1.00
36 Cryomodules
288 Cavities

SRF CAVITIES	8 GeV Linac				Spallation Neutron Source	
Number of Cavities in Linac	392	including 8 in debuncher cryomodule			elliptical	
Cavity type	elliptical			pi		
Cavity operating mode	pi			Niobium		
Cavity material	Niobium	RRR > 250? TBD		4 mm		
Cavity material thickness	4 mm	3.8 mm after processing		3.8 mm after processing		
Cavity final processing	electropolish					
Cavity stiffeners	yes			yes		
Allowed frequency swing due to Lorentz force	470 Hz			470 Hz		
Micromechanical amplitude limit	+/- 100 Hz	Six sigma		+/- 100 Hz		
Cavity operating temperature	~1.9 K			2.1 K		
Cryomodule Type (Beta)	LOW	MEDIUM	HIGH	"TESLA"	MEDIUM	HIGH
Geometrical Beta of Sections	0.47	0.61	0.81	1.00	0.61	0.81
RF frequency (MHz)	805	805	805	1207.5	805	805
Cavity Type	RIA	SNS061	SNS081	"TESLA"	SNS061	SNS081
Number of Cells Per Cavity	6	6	6	9	6	6
Cell-to-Cell Coupling Constant	1.50%	1.61%	1.61%	1.87%	1.61%	1.61%
Unloaded Qo	>5E9	>5E9	>5E9	>1E10	>5E9	>5E9
External Q	7.5E+05	7.3E+05	7.0E+05	1.5E+06	7.3E+05	7.0E+05
External Q Variation	+/- 20%	+/- 20%	+/- 20%	+/- 20%	+/- 20%	+/- 20%
R/Qo (function of beam velocity)	160	220-440	170-570	1036	220-440	170-570
Typical band width FWHM=f0/(2Qex)	537 Hz	551 Hz	575 Hz	403 Hz	550 Hz	575 Hz
Cavity Active Length (geometrical)	0.525 m	0.682 m	0.906 m	1.118 m	0.682 m	0.906 m
Cavity Total Length incl. Couplers	0.910 m	1.067 m	1.290 m	1.318 m	1.067 m	1.290 m
Cavity Slot Length incl. Bellows	0.990 m	1.155 m	1.380 m	1.370 m	1.158 m	1.381 m
Iris Diameter	77.2 mm	86.0 mm	97.6 mm	75 mm	77 mm	77 mm
ID at Equator	329 mm	329 mm	329 mm	223 mm	329 mm	329 mm
Epeak (max)	45	45	45	45	27.5	35.0
Epeak/Eacc	3.41	2.71	2.19	2.0		
Eacc (max, on crest for Beta-design)	13.2	16.6	20.5	22.5	MV/m	
Bpeak/Eacc	6.92	5.73	4.79	4.26	mT/(MV/m)	
Bpeak	91.3	95.1	98.4	95.9	mT	
Synchronous Phase Phi (typ)	-25	-22	-19	-16	deg	
Eacc*Cos(Phi)	12.0	15.4	19.4	21.6	MV/m	
Energy Gain Per Cavity (max)	6.3	10.5	17.6	24.2	MV	
Coupler Power (max) for 25mA Beam	157	262	440	605	kW	

SRF CRYOMODULES	8 GeV Linac					Spallation Neutron Source		
Number of Cryomodules	49		Linac + Debuncher					
Cryomodule Style	TESLA		modified by T Nicol for small GRP etc.			CEBAF		
Warm-Cold Beam Pipe Transitions	No					Yes		
Bayonet Cryo Disconnects & cold box	No					Yes		
Quadrupole Type	Cold		runs at 2K			Warm Doublet		
Cryostat Pipe Diameter (OD)	40 in.	1016 mm						
Cryostat Flange OD	46 in.	1168 mm						
Cryostat Material	Low Carbon Steel		de-Gaussed <i>in situ</i>					
Magnetic field at cryomodules from rebar	< 0.005 Tesla		low-carbon steel cryostat provides shielding					
Magnetic Shield Material around Cavities	cryoperm foil?							
Radiation Hardness	1.0E+08 Rads							
Cavity alignment tolerance WRT Cryomod	+/- 1 mm		TBD Maximum			+/- 1 mm	Maximum	
Cavity tilt tolerance relative to cryomodule	+/- 1 mrad		TBD Maximum			+/- 1 mrad	Maximum	
Cryomodule transverse alignment tolerance	+/- 1 mm		TBD Maximum			+/- 1 mm	Maximum	
Quad Alignment Tolerance WRT Cryomod	+/- 0.5 mm		TBD Maximum			N/A		
Transportation Distance from Factory	2 km		FNAL IB2 to Front-End Bldg.			800 km	TJNAF to ORNL	
CRYOMODULE TYPES	LOW	MEDIUM	HIGH	"TESLA"		MEDIUM	HIGH	
Cryomodule Geometrical Beta of Cavities	0.47	0.61	0.81	1.00		0.61	0.81	
Number of Cryomodules in Linac	2	3	7	36	48 incl. debuncher	11	12	
Spare Cryomodules	2	2	2	4				
Length of Cryomodule slot for each Beta	10.870	11.190	12.790	14.060		5.839m	7.891m	
Number of Cavities Per Cryomodule	8	8	8	8		3	4	
Number of Quads Per Cryomodule	9	5	3	2		2	2	warm doublet outside cryomodule
Slot Lengths								
Cavity Slot Length incl. Bellows	0.990m	1.155m	1.380m	1.370m		1.158	1.381	
Quad Assy Slot Lengths	0.250 m	0.250 m	0.350 m	1.200 m				
Beam Profile Monitor Slot Length	0.200 m	0.200 m	0.200 m	0.200 m	1/cryomod			
Cryostat Interconnect Length	0.500 m	0.500 m	0.500 m	0.500 m	TTF			
Cold Mass								
Cold Mass of Quad/BPM Assy	12 kg	10 kg	12 kg	43 kg	see quad sect			
Total 2K Cold Mass per Cryomodule	870 kg	895 kg	1023 kg	1125 kg	rough est.			
Total 5K Cold Mass per Cryomodule	54 kg	56 kg	64 kg	70 kg	rough est.			
Total 50K Cold Mass per Cryomodule	163 kg	168 kg	192 kg	211 kg	rough est.			
Heat Loads								
2 K static heat load per Cryomodule	11 W	11 W	11 W	5 W	317 W	25	28	W
2 K total heat load per Cryomodule	20 W	20 W	20 W	14 W	775 W	41	56	W
6K Static Heat Load per Cryomod	35 W	35 W	35 W	14 W	951 W			
6K Total Heat Load per Cryomod	29 W	29 W	29 W	23 W	1192 W			
50K Shield static heat load	273 W	221 W	195 W	118 W	6956 W	170	200	W
RF Coupler Type	~SNS	~SNS	~SNS	TTF	cond. cooled	SNS/KEK	SNS/KEK	
Coupler LHe consumption / cryomodule	-	-	-	-		0.225	0.3	g/s

SRF POWER COUPLERS		8 GeV Linac			Spallation Neutron Source
Cavities per Power Coupler		1 SNS modified for conductive instead of vapor cooling			1 KEK-B
Power coupler design		805	1207.5	MHz	805
RF Frequency		96	288	kW	81
Number of Couplers		450	600	kW	550 kW
Maximum Nominal power thru coupler		TBD	TBD	kW	
Tested power of coupler		50	50	Ohm	50 Ohm
Coax Impedance		+/-2.5kV	+/-2.5kV		+/-2.5kV
Bias Voltage on Center Conductor		WR975	WR770		WR975
Input Waveguide		none	none	Single RF Window Design	none Single RF Window Design
Power coupler vacuum		none	none	conductive cooling w/6K & 50K intercept	0.075 g/s vapor cooled
Liq. Helium Consumption per Coupler		0.75 W	0.75 W	W 288 W tot.	0.7 W
Static Heat Load at 2K		0.85 W	0.85 W	W 326 W tot.	0.8 W
Total Heat Load at 2K		2.79 W	2.79 W	W 1071 W tot.	
Static Heat Load at 6-8K		2.85 W	2.85 W	W 1094 W tot.	
Total Heat Load at 6-8K		9.80 W	9.80 W	W 3763 W tot.	
Static Heat Load at 50K		9.94 W	9.94 W	W 3817 W tot.	
Total Heat Load at 50K		No	No	not needed for 10Hz operation	yes, center conductor of coax
HOM COUPLERS		2 2 x 396 TTF (scaled to 805MHz and 1207.5 MHz)			2 2 x 81 TTF (scaled to 805MHz)
HOM HEAT LOADS		2K	6K	50K	
per coupler	0.34 W	0.87 W	4.69 W	Scaled from TTF	
	2.7 W	6.9 W	37.5 W		
	133 W	340 W	1838 W		
CAVITY TUNERS		384 +/-100 kHz 3000 Hz/min			81 +/-100 kHz 3000 Hz/min
Number of tuners		cold stepping motor in insulating vacuum			cold stepping motor in insulating vacuum
Mechanical Tuner Range		~200 kgf/mm			
Mechanical Tuner Slew Rate		yes			yes
Mechanical Tuner Actuator					
Cavity Spring Constant					
Fast Piezo Fine Tuners Included					

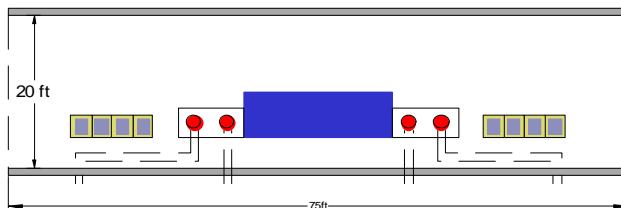
SRF LINAC QUADRUPOLES		8 GeV Linac				Spallation Neutron Source	
Number of Quadrupoles in Cryomodules		126 FODO				64 Doublet	
Focusing structure		Cold Superferric Quads inside cryomodules (MSU/TRASCO)				Includes doublets for unoccupied space	
Quadrupole type		both H & V each quad				Warm Copper Electromagnets between Cryomodules	
Trim Dipole Windings Inside Quads		+/-1 cm				both H & V each quad 32 Powered	
Trim Dipole Downstream Orbit Deflection		1 uT					
Stray Field at Cavites (quads unpowered)		10 uT					
Stray Field at Cavites (quads powered)		typical, varies along lattice during cavity cooldown after cavites are SC					
Cryomodule Type (Beta)		LOW	MEDIUM	HIGH	"TESLA"		
Number of Quads Per Cryomodule		9	5	3	2	2	
Number of Quadrupoles		18	15	21	72	=126+spares	
Quad Slot Length		0.250 m	0.250 m	0.350 m	1.200 m	0.39 m	
Quad Magnetic Length		0.150 m	0.150 m	0.250 m	1.100 m		
Quad Integrated Strength (at max energy)		3.05 T	2.51 T	2.70 T	3.0 T		
Quad Gradient at max energy		20.3 T/m	16.7 T/m	10.8 T/m	2.7 T/m	7.2 T/m typ	
Quad Aperture Radius		40 mm	40 mm	40 mm	40 mm	40 mm	
Quad Pole Tip Field at max energy		0.81 T	0.67 T	0.43 T	0.11 T		
H-minus Stripping Field at max energy		1.35 T	0.58 T	0.27 T	0.06 T		
Beam Radius for Stripping (at max energy)		67 mm	35 mm	25 mm	22 mm		
SRF Quadrupole Design Details							
Amps		25 A	25 A	25 A	25 A		
Amp-Turns per pole		12,923	10,638	6,864	1,736		
Turns/pole		517	426	275	69		
Stored Energy (approx)		198 J	134 J	93 J	26 J		
Inductance		0.6 H	0.4 H	0.3 H	0.1 H		
SC Strand Diameter (including Insulation)		0.50 mm	0.50 mm	0.50 mm	0.50 mm		
SC Coil Area (pole winding)		129 mm^2	106 mm^2	69 mm^2	17 mm^2		
SC Coil Azimuthal Thickness		15 mm	15 mm	15 mm	15 mm		
SC Coil Radial Thickness		9 mm	7 mm	5 mm	1 mm		
SC Coil Inner Radius		45 mm	45 mm	45 mm	45 mm		
Lamination Return Leg Thickness		16 mm	13 mm	10 mm	10 mm		
Lamination Outer Radius		70 mm	65 mm	60 mm	56 mm		
Approximate Weight		12 kg	10 kg	12 kg	43 kg		
SRF Magnet Current Leads							
Number of Leads per quad		4	4	4	4	2+Dipole trims	
Number of Leads per Cryomodule		36	20	12	8		
Number of Leads per Cryomodule Type		72	60	84	288	504 total	
2K Heat Load per cryomodule from Leads		0.25 W	0.14 W	0.08 W	0.06 W	3.5 W tot.	
50K Heat Load per cryomodule from Leads		32.50 W	18.06 W	10.83 W	7.22 W	455 W tot.	
Current Lead Type		HTS (BSCCO) conductively cooled with 50K Intercept					
Heat Leak per Lead to 2K		0.007 W / Lead		Scaled per Amp from TESLA TDR			
Heat Leak per Lead to 50K		0.903 W / Lead		Scaled per Amp from TESLA TDR			

8 GeV Linac			Spallation Neutron Source		
SRF CRYOGENICS	9.8 kW of 4.2K Equiv Refrigeration 1.3 MW at 10 Hz operation 0.7 MW static heat load only 2.6 MW 100% overcapacity for cool down, etc. 3 MW	2+1 48 hrs 18 hrs 50 m 1800 kg He 2500 kg He 2000 kg He	Upstream & downstream, +Test Stand Target Prelim. Est. TBD 100% rough est. 139% one 20,000 gal LHe dewar 111% eight 30,000 gal gas tanks	at 10 Hz Operation 23 (each cryomodule has indep cooldown & 2K coldbox) 8-12 hours ~4? hours for a single cryomodule 6-8 m each cryomodule	
CRYO FLOWS	2K 2.0 K 2.1 K 0.04 Bar 327 W 453 W 780 W 116 kW 0.17 684 kW 286 kW 2	6K 6.0 K 8.0 K 3 Bar 1081 W 395 W 1476 W 72 kW 0.25 289 kW 212 kW 2	50K 40 K 60 K 4 Bar 8216 W 4665 W 12881 W 84 kW 0.25 335 kW 214 kW 1.5	2K 2.1 K 2.1 K 0.04 Bar 0.0 g/s	5K 5.0 K 5.0 K 3.00 Bar 0.0 g/s
CRYOGENIC TRANSFER LINES	Cryo Plant To Linac across road	Linac to Debuncher in tunnel	Cryoplant to Test Stands cryoplant	2	2
WARM HELIUM TRANSFER LINES	Linac Cooldown in tunnel 900 m 4" IPS 2 Bar 4 Bar 6	to Tevatron and CHL overland ~1.5 km 4" IPS 2 Bar 4 Bar 4	Tevatron He connection is option TBD TBD TBD	1.5	1.5 2K Overcapacity @ 1.3 G

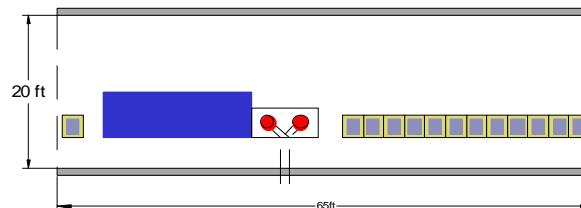
KLYSTRONS	8 GeV Linac			Spallation Neutron Source		
	45	linac(41) + debuncher(1) + test stands(3)	402.5 MHz, 805 MHz, and 1207.5 MHz	3	402.5 MHz	805 MHz
Number of Klystrons	45	linac(41) + debuncher(1) + test stands(3)	402.5 MHz, 805 MHz, and 1207.5 MHz	3	402.5 MHz	805 MHz
Number of Klystron Types	3	402.5 MHz, 805 MHz, and 1207.5 MHz	402.5 MHz, 805 MHz, and 1207.5 MHz	35	7	5
Number of Modulators	35	linac(31) + debuncher(1) + test stands(3)	linac(31) + debuncher(1) + test stands(3)	upstairs gallery or in side tunnel	81	0.55 MW
Location of Klystrons & Modulators	Linac Gallery					
Klystron Individual Details	402.5 MHz	805 MHz	1207 MHz		402.5 MHz	805 MHz
Number of Klystrons (main linac)	7	10	24	41 total	7	5
Number of Klystrons(test stand+debuncher)	1	1	2	4 total		
Klystron System Load	DTL & RFQ	Beta<1 SCL	Beta=1 SCL			
Klystron Peak Power	2.5 MW	5 MW	10 MW		2.5 MW	5.00 MW
Klystron Test Power	2.75 MW	5.5 MW	TBD			
Klystron Type	SNS	SNS	"TESLA"	* TESLA MBK modified to		
Klystron Reference Manufacturer	Marconi	Thales	Thales/CPI*	* operate at 1207.5 MHz		
Klystron Reference Model #	KP3525L	TH2168	TH-1801 *	* instead of 1300 MHz		
Klystron RF Pulse Width	1.1 msec	1.3 msec	1.3 msec			
Klystron Repetition Rate	10 Hz	10 Hz	10 Hz			
Klystron RF Duty Cycle	1.1%	1.3%	1.3%			
Klystron Power (average)	28 kW	65 kW	130 kW		150 kW	300 kW
Klystron Efficiency	50%	50%	60%			
Klystron Beam Voltage	125 kV	140 kV	117 kV			
Klystron Beam Current	40 A	71 A	142 A			
Klystron Number of Beams	1	1	7			
Klystron Perveance (Amps per V ^{3/2})	9.1E-07	1.4E-06	3.6E-06			
Klystron Gain	40 dB	40 dB	40 dB			
Klystron Bandwidth (1dB)	1.0 MHz	2.6 MHz	3 MHz			
Klystron Number of Internal Cavities	6	6	6			
Klystron Filament Voltage	35 V	35 V	9 V			
Klystron Filament Current	20 A	35 A	50 A			
Klystron Solenoid Power	5 kW	3 kW	5 kW			
Klystron Height	13.0 ft	13.0 ft	8.2 ft			

KLYSTRON GALLERY LAYOUTS (to scale)

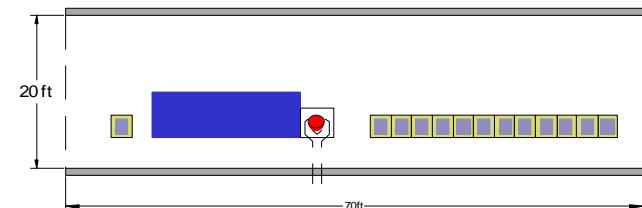
402.5 MHz (2 total)



805 MHz (5 total)



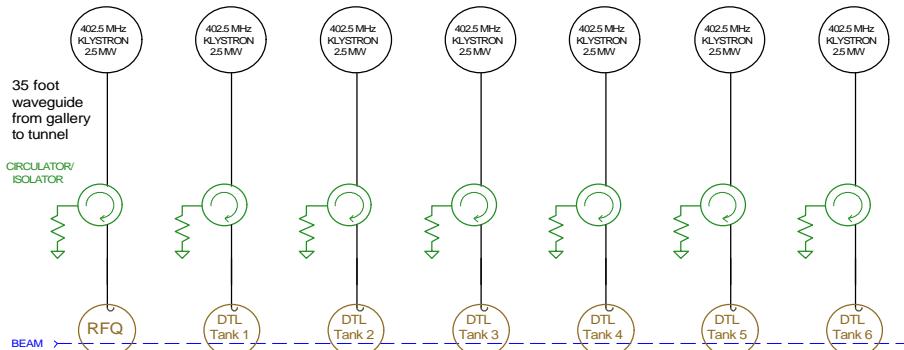
1207.5 MHz (24 total)



8 GeV Linac				Spallation Neutron Source
MODULATORS	402.5 MHz	805 MHz	1207 MHz	
Number of Modulators	35 total	linac(31) + debuncher(1) + test stands(3)		
Modulator Pulse Generator Varieties	1 type	standard for 402.5, 805, and 1207.5 MHz		
Modulator Peak Power	17-20 MW	depending on location in linac		
Modulator Average Power	275 kW	typ.		
Modulator Pulse Width	1.5 msec	typ.		
Modulator Output Voltage	10 kV	before step-up from pulse transformer		
Modulator Rep Rate	10 Hz			
Modulator type	IGBT bouncer			IGBT switcher
Modulator Flat Top Accuracy	+/- 0.5 %	maybe negotiable		
Modulator RMS Pulse-to-Pulse variation	+/- 0.2 % RMS	maybe negotiable		
Modulator Spark Protection for Klystron	Redundant IGBT switch with Ignitron Crowbar			
Modulator Max Fault Energy into Klystron(s)	20 J	including klystron capacitance		
Modulator Supply Voltage	480 VAC, 60 Hz, 3 Phase			
Modulator Charging Supply Type	SCR phase control with output filter and Power Factor correction			
Modulator Power Factor Correction	meeting FNAL standards for large installations			
Modulator Size (W x D x H)	18 x 6 x 8 ft	may be reduced with new caps		
Modulator LCW Circuits	2? TBD	1 modulator + 1 pulse transformer		
Modulator Individual Details	402.5 MHz	805 MHz	1207 MHz	
Number of Modulators	3	6	26	incl. Test Stand & Deb.
Number of klystrons per modulator	4	2	1	
Modulator Voltage	125 kV	140 kV	117 kV	
Modulator Current	160 A	143 A	142 A	
Modulator Peak Power	20 MW	20 MW	17 MW	
Modulator Test Power	TBD	TBD	TBD	
Modulator Average Power	260 kW	300 kW	250 kW	
Modulator HV Pulse Width (flat top)	1.1 msec	1.3 msec	1.3 msec	
Modulator Switch Conduction Time	1.3 msec	1.5 msec	1.5 msec	
Modulator Duty Cycle	1.3%	1.5%	1.5%	
Modulator Efficiency incl. Charging Supply	85%	85%	85%	
Modulator Wall Power (max)	306 kW	353 kW	294 kW	varies ~20% along linac
Total Modulator Wall Power Installed	0.9 MW	2.1 MW	7.6 MW	10.7 MW installed
Pulse Transformer Tanks	402.5 MHz	805 MHz	1207 MHz	402.5 MHz 805 MHz 805 MHz
Number of Tubes per Tank	4	2	1	1 1 6
Number of Transformers per tank	4	2	1	1 1 1
Tank Size (W x D x H) ft	20' x 4' x 4'	12' x 4' x 4'	8' x 4' x 4'	maybe cheaper to gang tubes
Transformer Ratio	1:13	1:14	1:12	assuming all tubes in 1 tank
Filament Windings per Transformer	1	1	1	
Height needed to remove Klystron	17 ft	17 ft	12 ft	tube height + 4ft
Tank Weight including Transformer(s)	TBD	TBD	TBD	
Tank Avg Power Dissipation	3 kW	3 kW	3 kW	from TESLA TDR fig 8.5.3
Tank Oil Inventory	~2000 liters	~1000 liters	~500 liters	
Oil Purification Method	Travelling cart			
Tank Moved for Klystron Replacement	NO			unlike FNAL linac upgrade

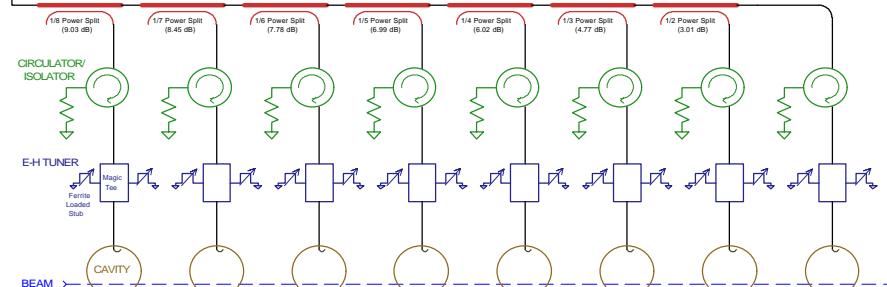
402.5 MHz RF FAN OUT

2.5 MW Klystron Feeds Single Cavity
 Single WR-2100 Waveguide from Gallery to Tunnel
 6 of this type Klystron installed in Linac



805 MHz RF FAN OUT

5 MW Klystron Feeds 8-12 Cavities
 Single WR-975 Waveguide from Gallery to Tunnel
 10 of this type Klystron installed in Linac



KLYSTRON

- RF Power Source
- Located in Gallery above tunnel
- Each Klystron Feeds 8-16 Cavities

DIRECTIONAL COUPLER

- Picks off a fixed amount of RF power at each station
- Passes remaining power downstream to other cavities



CIRCULATOR / ISOLATOR

- Passes RF power forward towards cavity
- Diverts reflected power to water cooled load



E-H TUNER

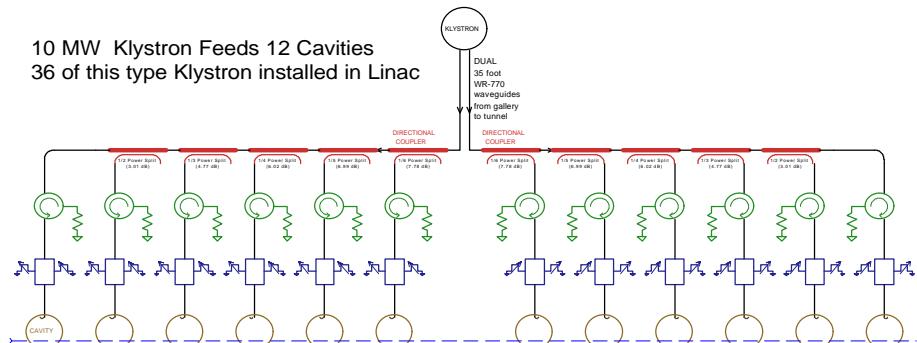
- Provides Phase and Amplitude Control for Cavities
- Biased Ferrite Provides Electronic Control

SUPERCONDUCTING RF CAVITY

- Couples RF Power to Beam

1207.5 MHz RF FAN OUT

10 MW Klystron Feeds 12 Cavities
 36 of this type Klystron installed in Linac



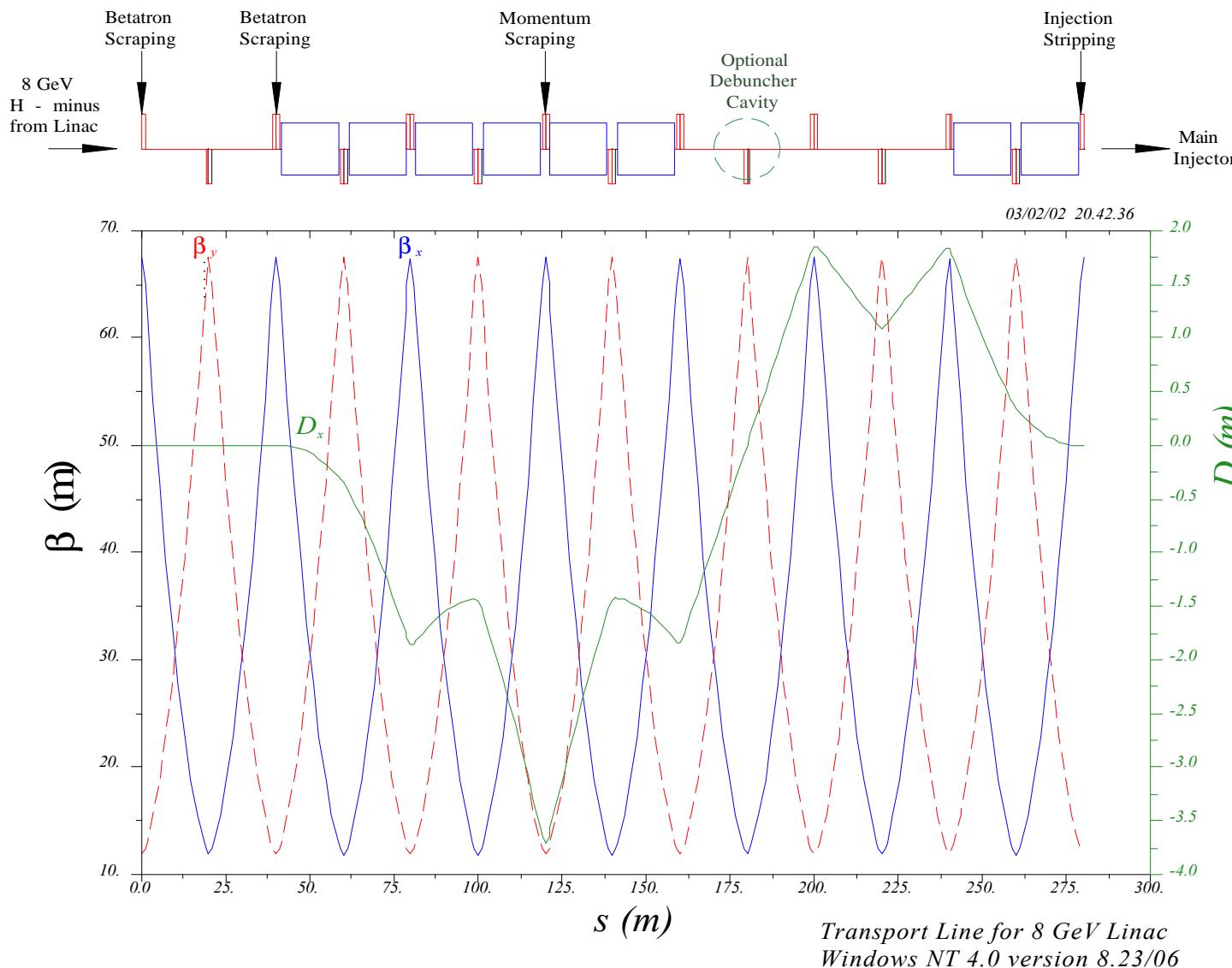
RF Distribution	8 GeV Linac			Spallation Neutron Source	
	402.5 MHz	805 MHz	1207 MHz		
Peak Power from Klystron	2.5 MW	5.0 MW	10.0 MW		2.5 MW
Cavities per Klystron	1	8 - 12	12		1
Number of Output Waveguides per Klystron	1	1	2		1
Waveguides per Microwave Chase	1	2	2		1
RF Distribution Efficiency (see below)	95%	87%	86%	incl. Ferrite Phase shifters	
Power Available at Cavity RF Coupler	2.38 MW	0.54 MW	0.71 MW	worst-case cavity in each grp.	
Peak Power Required at Coupler	1.80 MW	0.45 MW	0.60 MW	TESLA ~106%	
Excess RF Power Available after losses	132%	121%	119%		
Waveguide	402.5 MHz	805 MHz	1207 MHz		
Waveguide Type (in long chase & fanout)	WR2100	WR975	WR770	local components smaller	
Rated Waveguide Power @freq.	600 MW	120 MW	85 MW		
Max Power in Waveguide (at Klystron)	2.5 MW	5 MW	5 MW		
Average Power in Waveguide (at Klystron)	33 kW	75 kW	75 kW		
RF Distribution Losses	402.5 MHz	805 MHz	1207 MHz		
Average Waveguide Length	100 ft	125 ft	130 ft	incl. avg. length of fanout	
Nominal Attenuation dB/100ft @freq.	0.06 db/cft	0.20 db/cft	0.25 db/cft		
Waveguide Attenuation Losses	0.06 db	0.25 db	0.33 db	Dielectric Co. Catalog	
Power Splitter Directivity Losses	0.05 db	0.05 db	0.05 db		
Circulator Losses	0.10 db	0.10 db	0.10 db	0.08 meas. at TTF	
Ferrite Tuner Losses	N/A	0.20 db	0.20 db	quote from AFT	
Overall Losses (avg)	0.21 db	0.60 db	0.68 db		
percent power losses	5%	13%	14%		
RF Phase and Amplitude Adjustment	402.5 MHz	805 MHz	1207 MHz		
Phase / Amplitude Tuner Type	LLRF	Ferrite	Ferrite	LLRF control per Klystron	
Phase / Amplitude Tuner Locations	1 / klystron	1 / cavity	1 / cavity	LLRF control per Klystron	
Number of Phase / Amplitude Tuners	7	96	300		
Phase Tuner Adjustment Range (deg)	> 360 deg	400 deg	400 deg	for running electrons and H-	
Phase Tuner Slew Rate	>360deg/us	1 deg/usec	1 deg/usec	target	360 degree
Amplitude Tuner Attenuation Range	~inf	-10dB	-10dB	target	
Amplitude Tuner Slew Rate	>20db/usec	-0.1dB/usec	-0.1dB/usec	target TBD, varies w/setting	
Phase Tuner Peak Power	-	0.45 MW	0.60 MW		
Phase Tuner Insertion Loss	-	0.2 db	0.2 db	AFT quote	
Phase Tuner VSWR Loss	-	0.02 db	0.02 db	target	
Phase Tuner Avg. RF Power Dissipation	-	263 W	351 W	target	
Phase Tuner Coil Average Power Dissipation	-	40 W	40 W	target for 10Hz pulse rep rate	
Static RF amplitude error	+/-1%	+/-1%	+/-1%	TBD	+/-1 %
Static RF phase error	+/-1 deg.	+/-1 deg.	+/-1 deg.	TBD	+/-1 degree
Dynamic RF amplitude error	+/-0.5%	+/-0.5%	+/-0.5%	TBD	+/-0.5 %
Dynamic RF phase error	+/-0.5 deg.	+/-0.5 deg.	+/-0.5 deg.	TBD	+/-0.5 degree

SCRF INSTRUMENTATION	8 GeV Linac			Spallation Neutron Source	
Channels per Each CAVITY					
Forward & Reverse Power Monitors	per cavity	6	per linac	2352	including debuncher and 2 test stands
Coupler Spark Detector		2		784	2 @ Pwr Split, Tuner, & Input Coupler
Coupler IR detector		1		392	Appears SNS has this many?
Circulator Spark Detector		3		1176	
Resonance Detector		1		392	
Step Motor Tuner Drive		1		392	
Step Motor Tuner Readback		1		392	
Step Motor Tuner Limit Switches		2		784	
Piezo Tuner Drive		1		392	
Ferrite Tuner Drive		2		784	
Ferrite Tuner Power Monitor		2		784	
LCW Flow Meters		1		392	
Misc. Temperatures		5		1960	
Total Channels Per Cavity	28	10976			including debuncher and 2 test stands
Channels per Each CRYOMODULE	per CM		per linac		including debuncher and 2 test stands
BPM and phase monitors		2		98	
Beam loss monitors		1		49	
Beam Profile scanners		1		49	X-Y
Number of Cryo Temp Sensors		8		392	
Insulating Vacuum TC gages		1		49	
Coupler Vacuum Ion Pump		-		-	SNS coupler needs no coupler vacuum
Coupler Vacuum TC gage		-		-	SNS coupler needs no coupler vacuum
Alignment Readouts		4		196	TBD
Total Channels per Cryomodule	17	833			including debuncher and 2 test stands
Channels per Each KLYSTRON	per Klystron		per linac		including debuncher and 2 test stands
Vacuum		3		135	Readback, Interlock, Ion Gauge
Water Flow		3		135	Body, Collector, Solenoid
Solenoid Power Supply		3		135	PS control, PS Readback, Ground Fault
Filament		3		135	Control, Voltage Readback, Current Readback
Ion Pump Power Supply		1		45	
Waveguide Pressure		1		45	
Pulse Transformer		4		180	Temperature (2+Interlock), Oil Level
Pulse Transformer Bias Supply		2		90	Control & Readback
RF Leak Detector		3		135	
Gun Voltage and Current		2		90	Voltage divider & Current Transformer
RF Power (Directional Coupler)		2		90	Forward & Reverse power at Klystron
Total Channels per Klystron	27	1215			including debuncher and 2 test stands
Waveguide/Cable Chases	8 GeV Linac			Spallation Neutron Source	
Number of Waveguide Chases		35			
Number of Waveguides per Chase		2		(only one for 402.5 MHz Chases)	
Number of Cables per Chase		372	average	~80 of these are 3/8" Heliax	
Total Number of Cables		13024	approx		

WARM INSTRUMENTATION		8 GeV Linac	Spallation Neutron Source			
MEBT DIAGNOSTICS						
Number of beam current monitors	1		2			
Number of beam profile monitors	2	Two dual-plane monitors (laser wires?)	5	Includes one dual-plane laser wire		
Number of two-plane stripline BPMs	2	Inside quads, include phase measurement	6	Inside quads, incl. phase measurement		
Number of emittance scanners	1 TBD		1			
DTL DIAGNOSTICS						
Number of beam position and phase monitors	10		10			
Number of beam loss monitors	5		5			
Number of beam current monitors	6		6			
Number of wire scanners	5		5			
Number of Faraday cups	5		5			
TRANSFER LINE DIAGNOSTICS						
Number of Warm Quad Locations	18	transferline + MEBT				
Number of Warm BPMs	36	X-Y at each warm quad location				
Beam Loss Monitors	24	one per quad, two per dump				
Foil Collimation Stations in Transfer Line	3	Betatron(2) and momentum(1)				
Magnet Klixon Alarms	0	air-cooled magnets throughout				
Number of beam current toroids	8	including dumps				
WARM VACUUM		8 GeV Linac	Spallation Neutron Source			
VACUUM INSTRUMENTATION						
Vacuum sectors in Transfer Line	6	BetaScrape,Arc1,P-Scrape,Arc2,Dump, Inj				
Ion Pumps	18	One per quad Location				
TC gauges	6	One per vacuum sector				
gate valves	7					
Klystron Ion Pump Power Supplies						
Magnets & Power Supplies		8 GeV Linac	Spallation Neutron Source			
Power Supply Total						
DTL Steering Magnets	24	10 V	10 A	100 W	2400 W	
MEBT matching Quads	2	10 V	10 A	100 W	200 W	8
SRF Quadrupoles	126	2 V	25 A	50 W	6300 W	29
SRF Steering Trim Windings	252	+/- 2 V	5 A	10 W	2520 W	33
Transfer Line Dipole Bus (24 B1's @150A)	23	0.89 V	150 A	134 W	3071 W	
C-magnets on Transfer Line Dipole Bus	1	0.89 V	150 A	134 W	134 W	
Transferline Quad Bus (3Q52)	8	1.27 V	486 A	617 W	4938 W	
Transferline Matching Quads (3Q52)	8	1.27 V	486 A	617 W	4938 W	
Transferline Vertical Correctors	12	+/- 20 V	5 A	100 W	1200 W	
Transferline Horizontal Correctors	8	+/- 20 V	5 A	100 W	800 W	
Orbit Bump Painting supplies (1ms pulsed)	2	275 V	75 A	21 W Avg.	41 W Avg.	

TRANSFER LINE TO RING	8 GeV Linac	Spallation Neutron Source
Transfer Line Length to Ring	280 m	170 m
Injection Point to Main Injector	MI-32	SNS Accumulator Ring Straight Section
Transfer Line Total Bend	8.3 deg	90 deg
Quad Focusing	FODO	
Phase Advance per cell	90 degrees	
Half-cell length	20 m	
Number of half-cells	14	
Number of Bend half-cells	8	including injection bend cell
Beta-Max (H & V)	67 m	
Beta-Min (H & V)	12 m	
Dispersion at entrance and exit	0 m	
Dispersion Max (at momentum collimation)	3.7 m	
Vacuum Required	1E-07 torr	TBD for < 1e-4 beam loss from stripping
QUADRUPOLES in transfer line	14	
Quad Length	1.5 m	Main Ring 3Q52 without water cooling?
Quad Gradient	1.33 T/m	
Dipoles in transfer line	24	three per bend cell
Dipole Field	0.06 Tesla	limited by H-minus stripping at 8 GeV
Dipole Length	6 m	Main Ring B1 @150A without water cooling?
Horizontal Trims in transfer line	8 shunts	
Vertical Trim Magnets	7	
Horizontal Trims	7	
Collimation in Transfer Line	8 GeV Linac	Spallation Neutron Source
BETATRON COLLIMATION IN TRANSFER LINE		
Collimation Type	H-minus stripping foils followed by sweeping magnets	
Location	first 2 half-cells of transferline downstream of Linac	
Number of collimators	8	+/-X, +/-Y at 2 locations each
Phase advance between stations	90 degrees	
Beta Functions at collimation	60 m	scrape at Beta-max in each coord
Beam Size at Collimators (sigma)	1.8 mm	
Nominal Collimator settings	4.0 sigma	TBD
Disposal of Collimated Particles	7.1 mm at Linac Beam dump	radial from beam center ? Or downstream collar?
MOMENTUM COLLIMATION IN TRANSFER LINE		
Number of stations	1	
Location	midpoint of transferline bend (dispersion max)	
Dispersion at Collimation Point	3.7 m	
Collimation Type	H-minus stripping foils followed by sweeping magnets	
Number of collimators per station	2	+/-X
Beta Function (X) at collimators	65 m	same in X and Y
Betatron Beam Size at Collimators (sigma)	1.8 mm	same in X and Y
Nominal Collimator settings (betatron)	5.0 sigma	TBD
Nominal dP/P acceptance of Collimation	9.2 mm	from beam center
dP/P acceptance of Main Injector ring	+/-0.25 % +/-0.75 %	for no betatron amplitude measured

8 GeV Injection Line Optics with Betatron and Momentum Collimation



TRANSFERLINE OPTICS REWORK LIST:

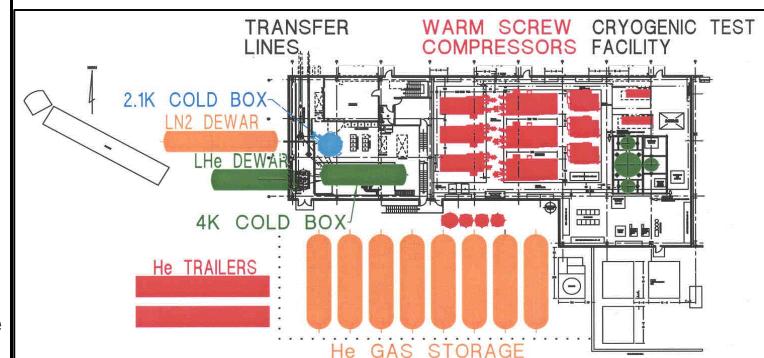
- 1) use exact lengths 3Q52 & B1's
- 2) Move Betatron scraping to midpoints between quads
- 3) more accurate match
- 4) injection sweeping magnets
- 5) indicate dump switch and c-magnet geometry
- 6) is Debuncher cavity ok with DPX <>0?

DEBUNCHER CAVITY	8 GeV Linac	Spallation Neutron Source
Status		
Location (Distance from end of linac)	OPTION INCLUDED IN BASELINE DESIGN & COST 180 m	INCLUDED IN BASELINE
Cavity Type	standard Beta=1 cryomodule	
Frequency	1207.5 MHz	
Beam Energy (kinetic)	8 GeV	gamma= 9.51
Gamma-T of transport line from linac	23.7	
Cavity Phase Change for dP/P = 1%	24.2 deg	adequately linear
Voltage required for 100% energy correction	190 MV	
Voltage available from cavity	203 MV	
Dispersion at Debuncher cavity	0 m	DPx nonzero but small
Feedback	none	debuncher runs open loop
Resonance Control	vector sum of 8 cavities in cryomodule	
Energy Spreader Cavity	none	modulate linac LLRF if necessary
LINAC BEAM DUMP	8 GeV Linac	Spallation Neutron Source
Model for Cost Estimate	Main Injector Beam Dump	
Location	~straight downstream of Linac, outside of transferline bend	
Beam Energy	8 GeV	electrons, H-, or (stripped) Protons
Average Total Beam Power (max)	2 MW	electrons + H-/Proton
Core Material	graphite/aluminum	
Shielding Material	steel/cement	
Cooling	RAW, heat exchanged with Tunnel LCW in beam stop enclosure	
RAW Circulation Flow at Full Beam Power	1500 liters/min	396 GPM on demand
RAW Delta-T	20 deg C	36 deg F
LCW Flow	1982 liters/min	524 GPM
LCW Delta-T	10 deg C	18 deg F
H- INJECTION TO RING	8 GeV Linac	Spallation Neutron Source
Injection Point	MI-302 Quad Location (F)	
Injection Bend	Vertical	
Injection Method	Foil Stripping	
Number of turns	90	
Foil Material	Diamond	
Foil Thickness	1 micron	
Peak Temperature of Foil	2500 degK	TBD

Emittances & Alignment	8 GeV Linac		Spallation Neutron Source	
Output H & V rms emit. w/errs, w/o jitter		pi mm-mrad	0.41 pi mm-mrad	
Output transverse centroid jitter		mm	+/- 0.25 mm	
Output H & V rms emit. w/errs & jitter		pi mm-mrad	0.45 pi mm-mrad	
Output L rms emit. w/errs		pi MeV-deg At 805 MHz	0.6 pi MeV-deg At 805 MHz	
Output rms energy spread		MeV	0.33 MeV	
Maximum output energy jitter	MeV	99.99%	+/- 1.5 MeV	99.99%
Maximum phase centroid jitter	deg	At 1207 MHz; 99.99%	+/- 3.7 deg	At 805 MHz; 99.99%
Beam halo outside 5 sigma transv.			< 1x10-4	
Beam residual inside chopper gap			< 1x10-4	
Quad gradient err rms max	%	Limit +/- 0.25 %	0.14 %	Limit +/- 0.25 %
Quad transverse err rms max	mm	Limit +/- 0.13 mm	0.07 mm	Limit +/- 0.13 mm
Quad roll rms max expected	mrad	Limit +/- 5 mrad	3 mrad	Limit +/- 5 mrad
Quad tilt rms max expected	mrad	Limit +/- 10 mrad	6 mrad	Limit +/- 10 mrad

CIVIL (Underground)	8 GeV Linac	Spallation Neutron Source
BEAM LINE TUNNEL		
Model	Main Injector MI-60 Straight section	
Width (inside)	15.00 ft 4.57 m same as MI-60	
Height (inside)	11.00 ft 3.35 m 2' taller than MI-60	
Length (total)	3287 ft 1002 m	
Drop Hatch & Front-end Bldg	98 ft 30 m	
Front End & Warm Linac	138 ft 42 m	
SCRF Main Linac	2133 ft 650 m	
Transfer Line to Tunnel	919 ft 280 m	
Location	~Tangent to MI-30 straight section	
Altitude of floor above sea level	713 ft 217 m	Main Injector Depth
Floor Depth Below Grade	29 ft 8.8 m	may be deeper depending on siting
Berm Height above Grade	4 ft 1.22 m	unnecessary for first 250m of tunnel
Number of Microwave Chases	35	
Stairwell spacing for Personnel Egress	500 ft 152.40 m	8 total
Bend	none	
Equipment Drop Hatch	one, 18m long, inside Front-End Building, in line with tunnel	
KLYSTRON GALLERY TUNNEL		
Model	Slip-Cast Cut & Cover, sharing excavation with Beam Tunnel	
Height (inside) for upstream 150m gallery	17.00 ft 5.18 m	needed for replacing 805 MHz Klystron
Aisle Height for upstream 150m gallery	14.00 ft 4.27 m	needed for transporting 805 Klystron
Height (inside) for rest of gallery	13.00 ft 3.96 m	needed replacing for 1207 MHz Klystron
Aisle Height for rest of gallery	9.00 ft 2.74 m	needed for transporting for 1207 Klystron
Width (inside)	20.00 ft 6.10 m	10ft aisle +6ft modulator +4ft back aisle
Aisle Width	10.00 ft 3.05 m	
Modulator Width	6.00 ft 1.83 m	modulator is bigger than klystron or rack
Back Side Aisle Width	4.00 ft 1.22 m	permits modulator chassis door opening
Length (total)	2756 ft 840 m	FEB to end of optional expansion drift
Floor altitude above sea level	745.0 ft 227.1 m	Entire gallery same height for klystron move
Door Spacing for Personnel Egress	500 ft 152.40 m	6 total
Crane Coverage	none	Klystron Service w/portable crane
BEAM STOP ENCLOSURE		
Model	Main Injector Beam Stop Enclosure	
Height	16.00 ft 4.88 m	same as MI
Width	21.00 ft 6.40 m	same as MI
Length	52 ft 160 m	same as MI
Altitude of floor above sea level	705.00 ft 214.88 m	9 ft. below Tunnel Floor, same as MI dump
Floor Depth Below Grade	38.00 ft 11.58 m	
Beam Line Height above Floor	7.00 ft 2.13 m	
Stairwells for Personnel Egress	1 + exit to beam transport line tunnel	
Drop Hatch	TBD	

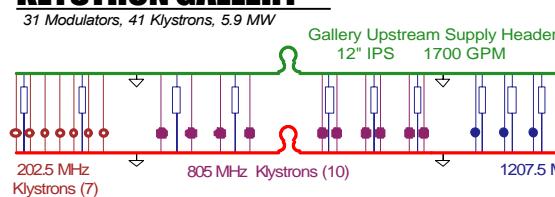
CIVIL (Above Ground)	8 GeV Linac	Spallation Neutron Source
FRONT-END BUILDING		
Model	Metal sided building w/crane & eqpt. drop to tunnel (like MI-60)	
Location	at head of Linac, off Giese Road	
Length (along Beam Line Direction)	125.00 ft 38.10 m	
Width (perp. To Beam Line)	50.00 ft 15.24 m	
Height (overall)	30.00 ft 9.14 m	smaller over office space
Height (crane hook height)	23.00 ft 7.01 m	needed for Klystron Replacement
Area with Crane Coverage	50 x 75ft	no coverage over office area
Garage Door height for Equipment	15 ft 4.57 m	
Equipment Drop Size	15ft x 60ft	needed for 16m Cryomodule
Crane Payload	20 tons	
Freight Elevator	like MI-60	
Floor altitude above sea level	#REF! #REF!	same as Klystron gallery
Personnel Doors for Egress	4	
Parking Lot	paved for 10 cars; unpaved for ~40	
TRANSPORT LINE SERVICE BUILDING		
Model	MI Power Supply Building	
Location	Near Debuncher & Abort Enclosures (~100m from injection point)	
Length (along Beam Line Direction)	50.00 ft 15.24 m	
Width (perp. To Beam Line)	50.00 ft 15.24 m	
Height (overall)	15.00 ft 4.57 m	needed for changing out 1207 Klystron
Area with Crane Coverage	none	special crane for Klystron change
Area for Office Space	none	
Garage Door height for Equipment	12 ft 3.66 m	
Floor altitude above sea level	742.00 ft 226.16 m	not critical
Personnel Doors for Egress	2	
Parking Lot	paved for 4 cars	
Power Transformers installed Nearby	1 MW	more than needed
CRYOPLANT / WATER PUMP BUILDING		
Model	SNS Cryoplant Bldg (Metal sided building w/crane) (use for cost)	
Location	Halfway Along Linac Active Length	
Length (along Beam Line Direction)	125.00 ft 38.10 m	
Width (perp. To Beam Line)	50.00 ft 15.24 m	
Height (overall)	30.00 ft 9.14 m	
Height (crane hook height)	20.00 ft 6.10 m	
Area with Crane Coverage	TBD	
Area for Office Space	TBD	
Garage Door height for Equipment	15 ft 4.57 m	
Floor altitude above sea level	742.00 ft 226.16 m	not critical
Personnel Doors for Egress	3 - 4	
Parking Lot	paved for 15 cars + 2 Gas Trucks	
Power Transformers installed Nearby	4MW	~2MW cryo + 0.5MW water pumps + spare
Gas Storage Tanks Outside	~8	
Liquid He Storage Tank	TBD gal	
Liquid N2 Storage Tank	TBD gal	
Transferline to Tunnel		

SNS CRYOPLANT BUILDING

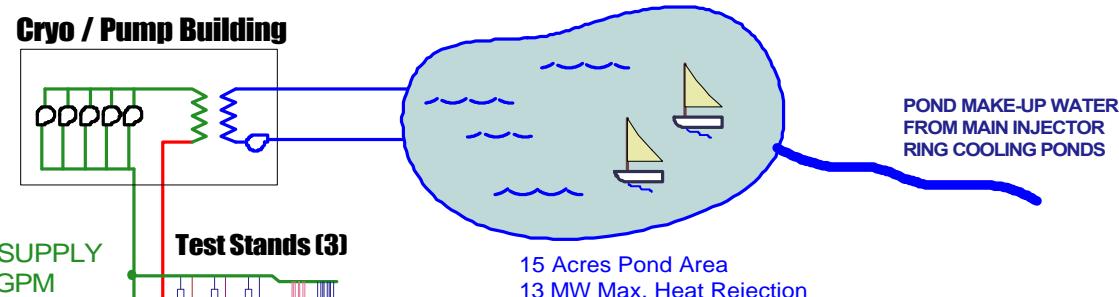
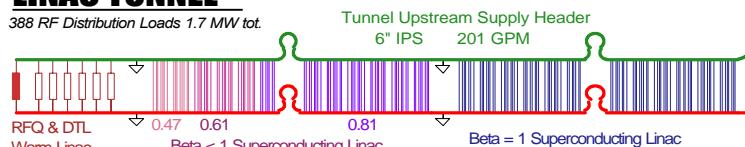
LCW Cooling System	8 GeV Linac	Spallation Neutron Source
Pump Room Location	Cryo/Pump Building at Linac Midpoint	
Total Heat Rejection by LCW	10.2 MW plus LCW pump power	
Total LCW Flow	15585 l/m 4118 GPM	
Average LCW Temperature Rise	9.4 degC	
LCW Pump Wall Power (60% eff)	131 kW	Main Injector: 1350 kW
LCW Supply Temperature (nominal)	32 degC	90 degF (same as MI)
LCW Return Temperature (nominal)	41 degC	106 degF
LCW Max. Temp (anywhere in system)	47 degC	117 degF
LCW Supply Pressure (nominal)	6.0 Bar	84 PSI
LCW Return Pressure (nominal)	3.0 Bar	42 PSI
LCW Relief Pressure (max rated)	8.0 Bar	112 PSI
Makeup/Fill Supply Source	Main Injector Tunnel	
LCW Conductivity (max)	1 Mohm-cm	
Number of Circuits in Klyston Gallery	2	upstream, downstream
Number of Circuits in Tunnel	2	(upstream+DTL) & (downstream+dump)
Number of Circuits in Test Stand	1	
LCW HEADERS		
Gallery Upstream Header Totals	3571 kW	6458 l/m 1706 GPM 7.9 degC
Gallery Downstream Header Totals	2284 kW	4410 l/m 1165 GPM 7.4 degC
Tunnel Upstream Header Totals	795 kW	759 l/m 201 GPM 15.0 degC
Tunnel Downstream LCW Totals	2903 kW	2773 l/m 733 GPM 15.0 degC
Test Stand LCW Totals	628 kW	1184 l/m 313 GPM 7.6 degC
LCW SYSTEM TOTAL	10,180 kW	15,585 l/m 4118 GPM 9.4 degC

8 GeV Linac Water Cooling System

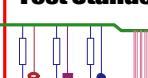
KLYSTRON GALLERY



LINAC TUNNEL

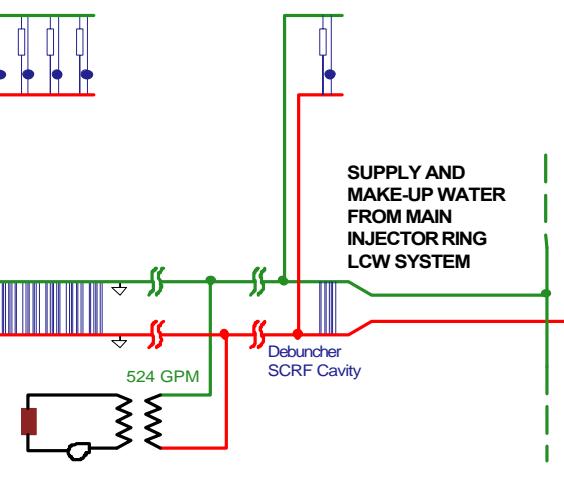


Test Stands (3)



15 Acres Pond Area
13 MW Max. Heat Rejection

Debuncher Cavity Service Building



358 m 337 m 280 m

GALLERY LCW LOADS		8 GeV Linac				Spallation Neutron Source
402.5 MHz RF STATION						
Number of Modulator Rf Stations	2					
Modulator Chassis	46 kW	43.8 l/m	11.6 GPM	15 degC		
Pulse Transformer	3 kW	2.9 l/m	0.8 GPM	15 degC		
Number of Klystrons/modulator	3.5				on average	
Klystron Collector	28 kW	113.6 l/m	30.0 GPM	3 degC		
Klystron Body	8 kW	9.1 l/m	2.4 GPM	15 degC		
Klystron Solenoid	5 kW	10.0 l/m	2.6 GPM	15 degC		
<i>RF Station Total</i>	<i>191 kW</i>	<i>510.92 l/m</i>	<i>135.0 GPM</i>	<i>15 degC</i>		
Total all 402.5 MHz RF Stations In Gallery	381 kW	1021.8 l/m	270.0 GPM	5.3 degC		
805 MHz RF STATION						
Number of Modulator Rf Stations	5					
Modulator Chassis	53 kW	50.6 l/m	13.4 GPM	15 degC		
Pulse Transformer	3 kW	2.9 l/m	0.8 GPM	15 degC		
Number of Klystrons/modulator	2				TESLA TDR	
Klystron Collector	65 kW	110.0 l/m	29.1 GPM	8 degC		
Klystron Body	8 kW	7.6 l/m	2.0 GPM	15 degC		
Klystron Solenoid	3 kW	2.9 l/m	0.8 GPM	15 degC		
<i>RF Station Total</i>	<i>208 kW</i>	<i>294.46 l/m</i>	<i>77.8 GPM</i>	<i>15 degC</i>		
Total for all 805 MHz RF Stations In Gallery	1040 kW	1472 l/m	389.0 GPM	10.1 degC		
1207 MHz RF STATION						
Number of RF Stations	24					
Modulator Chassis	44 kW	42.1 l/m	11.1 GPM	15 degC		
Pulse Transformer	3 kW	2.9 l/m	0.8 GPM	15 degC		
Klystron Collector	103 kW	250.0 l/m	66.1 GPM	6 degC	Thales	
Klystron Body	8 kW	10.0 l/m	2.6 GPM	11 degC	Thales	
Klystron Solenoid	5 kW	10.0 l/m	2.6 GPM	7 degC	Thales	
<i>RF Station Total</i>	<i>163 kW</i>	<i>315.0 l/m</i>	<i>83.2 GPM</i>	<i>7.4 degC</i>		
Total for all 1207 MHz RF Stations In Gallery	3915 kW	7560.4 l/m	1997 GPM	7.4 degC		
TUNNEL LCW LOADS		8 GeV Linac				Spallation Neutron Source
DTL + RFQ Cooling Load in Tunnel		193 kW	184 l/m	49 GPM	15.0 degC	
TUNNEL CAVITY STATION (1207 MHz)		One Circuit for (Circulator + Ferrite Tuner +Water Load Absorber) in series				
Number of Cavity RF Stations in Tunnel	392	assume all stations are like 1207 MHz (pessimistic)				
Circulator	0.2 kW					
Ferrite Tuners	0.4 kW	sum of 2 tuners with 0.2dB total losses				
Water Load	3.6 kW					
<i>Total per Cavity</i>	<i>4.1 kW</i>	<i>4.0 l/m</i>	<i>1.0 GPM</i>	<i>15 degC</i>		
Total for all Cavity Stations in Tunnel	1623 kW	1550.5 l/m	409.6 GPM	15.0 degC		
BEAM DUMP RAW System		2075 kW	1982 l/m	524 GPM	15 degC	
Beam Stop Location	Along Transfer Line to Ring					
Pump & Heat Exchanger Location	In Beam Dump Enclosure					
Beam Heat Load (design)	2 MW	worst case during comissioning				
Beam Heat Load (typical)	<10 kW	typical during running				
RAW Pump Heat Load	75 kW	100 HP WAG				
Heat Exchanger	With Downstream LCW flow in tunnel					

Pond Water HTX System	8 GeV Linac	Spallation Neutron Source			
Pump Room Location	Cryo/Pump Building at Linac Midpoint				
Cooling Method	Pond Evaporation				
Pond Makeup/Fill Supply Source	Main Injector Ring Ponds				
Pond Maximum Temperature	30.0 degC	86 degF			
Total Heat Rejection	12.7 MW	including cryo			
LCW Heat Load	10.2 MW				
Cryoplant Heat Load	2.0 MW				
Pump Power Load (LCW+ICW)	0.5 MW	TBD			
Heat Rejection Pond Area	15.0 acres				
HVAC	8 GeV Linac	Spallation Neutron Source			
Building Environmental Requirements					
Ambient Temperature	FE Bldg. 70 deg F 21 deg C	Gallery 85 deg F 29 deg C	Cryo Bldg. 85 deg F 29 deg C	Tunnel 80 deg F 27 deg C	XferLine 70 deg F 21 deg C
Allowed Temperature Variation	+/-10 degF +/-6 degC	+/-5 degF +/-3 degC	+/-10 degF +/-6 degC	+/-5 degF +/-3 degC	+/-10 degF +/-6 degC
Relative Humidity	50%	50%	50%	50%	50%
HVAC Heat Load	TBD	146 kW	TBD	207 kW	TBD
Air Changes per Hour	0.2	1.0	0.2	1.0	1.0
HVAC HEAT Loads	8 GeV Linac	Spallation Neutron Source			
Total Heat Rejection by HVAC Systems	353 kW	technical loads from Linac Only			
GALLERY HVAC HEAT LOAD	146 kW				
Number of RF Stations (Modulators)	35				
Control Racks	3000 W	WAG			
Corrector Supplies	150 W				
Ferrite Tuner Supply	100 W				
Klystron Filament Supply	200 W	(assume all stations are equal to 1207 MHz version)			
Klystron Solenoid Supply	200 W				
Gallery Lighting	500 W	watts of lighting per 16m of gallery			
<i>RF Station Total</i>	4.2 kW				
TUNNEL HVAC HEAT LOAD	207 kW				
Number of Cavity RF Stations in Tunnel	392	assume all stations are like 1207 MHz (pessimistic)			
Waveguide Losses per Cavity	270 W				
Air-cooled Reverse-power Load	200 W				
Power Supply Cables (avg per cavity)	8 W				
Tunnel Lighting	50 W	watts of lighting per 2m of tunnel			
<i>Tunnel HVAC Load Per Cavity</i>	0.53 kW				